Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

CHEMISTRY OF THE BLOOD ONE HUNDRED YEARS AGO

By GEORGE R. COWGILL, Ph. D.
YALE UNIVERSITY

THE recent appearance of a paper[1] discussing the chemical changes which occur in the blood concomitant with various disease conditions calls to mind a series of studies of this fluid made one hundred years ago. In 1821, the leading Swiss scientist of the time, J. L. Prévost, and his student, J. B. A. Dumas, who became the foremost French chemist during the middle of the nineteenth century, published in the "Bibliothéque Universelle, Sciences et Arts," volumes seventeen and eighteen, a series of three papers entitled "Examen du Sang et Son Action dans les Divers Phénomènes de la Vie."[2] To the present-day mind these papers are interesting not merely because they are accounts of studies made one hundred years ago, but because they touch upon a variety of topics, each of which in the course of a century's progress has attained to a greater or lesser degree the rank of a separate science. It would serve no purpose to point out the several paths followed in this development; those who are at all familiar with the history of the natural sciences, particularly chemistry, realize that they must read the nineteenth century in its entirety if they would know the complete story of that development.

In their earliest communication Prévost and Dumas state that the relation of the blood to the nervous system is primarily the subject of their research. Inasmuch as the changes occurring in this master tissue were believed to be slight and difficult to detect, the blood was made the special object of study. The first paper of the series deals with certain purely physiological and morphological aspects of the study together with an account of some experiments concerning blood transfusion. In the second article are presented the results of chemical analyses, while the last communication deals essentially with the phenomenon of secretion.

The conception of the general character of the blood as a fluid containing many minute red globules suspended therein was an inheritance from the early micrographers. Prévost and Dumas were unable to see how the fluid portion of the blood could influence the nervous system, and therefore easily persuaded themselves that a study of the *red globules* could furnish the desired information regarding the action of the blood during life. In the morphological studies which were made, the shape of the blood corpuscles was the first point to receive attention. Sir E. Home had set forth the view in his Croonian Lecture for 1818[3] that the red blood cells are spherical bodies ''composed of a central globule and a coloring-matter envelope.'' During the latter part of the eighteenth century Hewson had published an account of observations of the blood and had considered the corpuscles as flat plates furnished with a ''saillant'' point in their center. By this ''saillant'' point was doubtless meant what we now understand as the nucleus, for, as Prévost and Dumas remark, Hewson was led to this view as a result of examining the blood of the toad and the frog, forms in which the erythrocytes are recognized by present-day histologists as being nucleated. In order to determine which of these two views was the correct one, Prévost and Dumas examined the blood of forty-five different species of animals. Descriptions were given for each sample and the corpuscles were measured. The measurements were made by means of a camera-lucida arrangement, the object being traced on the camera-lucida field and its real dimensions deduced by a knowledge of the magnification employed. It is interesting to compare the diameter of the human erythrocyte as determined by these investigators with that given in modern textbooks. Prévost and Dumas obtained 6.6 microns as their result while present-day textbooks state approximately 7.5 microns. The smallest value noted by these workers was 3.8 microns, this being the diameter of the erythrocyte in the goat *Capra Hircus.*

---

[1] Myers, V. C.: *Journ. Lab. Clin. Med.*, V, 343 (1920).

[2] XVII, 215, 294. XVIII, 208.

Some of the conclusions reached were as follows: the globules are circular in shape in all mammals, their size varying among different species; they are elliptic in birds with but slight variation in size in this class; in all cold-blooded animals the erythrocytes are elliptic in shape.

Blood transfusion as a therapeutic measure has had a long history. The success of the operation was never assured, however, until comparatively recent times; there were unknown factors operating, when blood from one individual was introduced into the vessels of another, which too often led to fatal results. This was particularly true a century ago and earlier, when the blood of animals was occasionally transfused into the human being. With the discovery by Prévost and Dumas that demonstrable morphological differences exist among the bloods of different animals, it was natural for them to assume that such differences accounted for the varying results obtained when blood was transfused. They performed a series of experiments to test this idea. It was shown: (1) that in general, transfusion of blood between animals of the same species is a complete success; (2) that between animals having "globules" of the same shape but of different dimensions transfusion after severe hemorrhage results in only a partial relief of short duration; while (3) injection of circular "globules" into a bird results in death following "violent nervous symptoms comparable to those obtained after the administration of the most intense poisons."

---

[3] *Philosophical Transactions, 1818,* 172 & 185.

In their chemical examination of the blood Prévost and Dumas fixed their attention upon "l'albumine"[4] of the serum and the "coloring matter which surrounds the globule." As would be expected, no very exhaustive examination of these substances could be made considering the fact that suitable methods for analyzing organic compounds were not available. The name "l'albumine" was being applied to a complex something contained in the blood serum largely because it possessed the property of coagulating under the influence of heat in a manner similar to egg-white, and indeed, very little more was known concerning this substance. The coagulation temperature of "l'albumine" of the serum was determined to be 75° Centigrade.

Analyses of a general character were made upon the blood of twenty different species of animals; both the whole blood and the serum were analyzed for "eau, particules," and "albumine et sels solubles." In analyzing different samples of blood from the same animal it was noticed that the results did not always agree. It was reasoned that under certain conditions the veins must absorb considerable blood material; experiments were therefore performed to see how quickly the animal body could regenerate blood. Successive hemorrhages were made and the blood samples which were drawn at intervals were analyzed. The only change worthy of note was the content of corpuscles in the whole blood; the difference was slight, however, and Prévost and Dumas concluded that the veins are able to absorb blood material rapidly. In the light of modern physiology it would be said that these experimenters obtained a decrease in the erythrocyte content of the blood. An examination of the serum analyses submitted shows that remarkably constant values were obtained for the water and the albumen. The following conclusions are of interest: (1) arterial blood contains more "particules" than does venous blood; (2) the blood of birds contains relatively the largest number of "particules"; (3) the blood of mammals comes next and among them the carnivora seem to have more than the herbivora, while (4) the cold-blooded animals appear to possess relatively the smallest number.

---

[4] This should doubtless be translated as "albumen," which is used by modern physiological chemists in a generic sense; it is quite clear, however, that Prévost and Dumas considered "l'albumine" to be a single substance.

Three experiments were performed in studying the coloring matter of the blood.

> "(1) When ashed in an open crucible . . . . there resulted a considerable quantity of red powder more or less rich in peroxide of iron according to the nature of the blood employed; (2) when treated by boiling nitric acid so as to destroy the animal matter, a clear colorless fluid resulted in which a few drops of prussiate of ammonia formed a large amount of blue precipitate; (3) when dissolved by means of caustic potash and the resulting solution boiled with prussiate of ammonia, a brown liquor was obtained, in which the addition of a quantity of oxalic acid sufficient to saturate the potash brought about a precipitate of a greenish-blue color, which was nothing else than the albumen colored by the prussian blue."

All of these experiments confirmed the idea that the coloring matter of the blood "est formée d'une substance animale en combinaison avec le péroxide de fer." It was suggested that this animal matter might be "l'albumine" although the caution of these authors prevented them from being dogmatic on this point; they preferred to leave the question open for future research to decide.

When considering the phenomenon of secretion and the behavior of egg-white through which is passed a galvanic current, Prévost and Dumas approached the problem with the formula which was current at that time. The interesting topic of the day was electricity. Davy discovered the power of the electric current to decompose potash and soda in 1806; Oersted observed the effect of an electric current on a magnet in 1819; Ampère followed this in 1820 by showing that the direction in which a magnet moves depends upon the direction in which the electric current flows relative to the magnet. This dominating interest in electricity in 1821 is easily revealed by a perusal of the volumes in which the papers of Prévost and Dumas appeared; there are to be found papers by such men as Ampère, Arago, Oersted, Davy and Faraday.

Prévost and Dumas were not immune against this electric virus; they were interested in the experiments reported by an investigator who had tested the effect of a galvanic current on egg-white. The current had decomposed the egg- white, "the coagulated albumen wandered to the positive pole, and the caustic soda to the negative pole." This experiment was interpreted by the students of that early day to mean "that the white of egg is to be regarded as an albuminate of soda with excess of base.'' Prévost and Dumas repeated this experiment and examined microscopically the coagulum which collected about the positive pole. They found globules similar to those found in milk, pus, blood and muscle. This observation led them to make a generalization concerning the phenomenon of secretion.

> Nous considérons la surface circulante de chaque organe sécréteur comme douée d'une polarité constante en vertu de laquelle les produits de la sécrétion sont formés et isolés. Et si l'on se rappelle que les mucus et les produits non globuleux sont généralement alkalins; que, d'un autre coté le lait, le pus trés-sain, le chyme, et les muscles, sont globuleux et acides, on reconnoitra la plus grande analogie entre leur formation et celle des deux corps que nous obtenons dans l'experience galvanique sur l'albumine.

Just as evolution has been the formula of the past half century with which to explain all things, physical or metaphysical, animate or inanimate, and appears about to give way to a new formula, namely, relativity, so electricity was the formula one hundred years ago. There is in the passage cited above, in which polarity was brought into relation with secretion, simply an attempt at using the formula of the time. Another very interesting use of this formula is to be found in the closing chapter of Thomson's History of Chemistry published in 1830.[5]

> From the mouth the food passes into the stomach, where it is changed to a kind of pap called *chyme.* The nature of the food can readily be distinguished after mastication; but, when converted into chyme, it loses its characteristic properties. This conversion is produced by the action of the eight pair of nerves, which are partly distributed on the stomach; for when they are cut, the process is stopped: but if a current of electricity, by means of a small voltaic battery, be made to pass through the stomach, the process goes on as usual. Hence the process is obviously connected with the action of electricity. A current of electricity, by means of the nerves, seems to pass through the food in the stomach, and to decompose the common salt which is always mixed with the food. The muriatic acid is set at liberty, and dissolves the food; for *chyme* appears to be simply a solution of the food in muriatic acid.

The first definite proof—as far as the writer has been able to determine—that urea exists in the blood was furnished by Prévost and Dumas exactly one hundred years ago. In the third paper of the series under consideration, these authors described certain experiments in which both kidneys were removed from animals (dogs, cats and rabbits). Analysis of the blood of such animals showed the presence of a large amount of urea which was separated by means of the nitrate method; the urea was identified by determining its properties and by performing an elementary analysis. From the blood of unoperated animals, on the other hand, no such substance could be isolated.

---

[5] Page 319.

The significance of their discovery was fully appreciated and the authors discussed its bearing on the theory of renal secretion. The failure of other experimenters to show the presence of urea in the blood of normal animals had been interpreted to mean that the substance was not present in the blood but was formed in the kidney; the same idea of kidney function was held by Berzelius who maintained that the kidney was the organ for oxidizing sulphur and phosphorus (considered by him to be elements of albumin) since sulphates and phosphates were found in the kidney secretion in relatively large amounts but were absent from normal blood. Prévost and Dumas concluded that urea was eliminated by the kidney to a degree corresponding to its formation *elsewhere in the body:* ablation of both kidneys, as had been performed in their experiments, resulted in a failure of the body to eliminate this substance and consequently its accumulation in the blood in a quantity sufficient to enable its isolation and identification. This new point of view, namely, that the kidney functions to eliminate substances which are already present in the blood, they felt was supported by the evidence obtained from the study of gout. The existence of sodium "lithate" calculi in the joints was considered as evidence for the existence of sodium "lithate" in the blood. Since the secretion from the kidney contained sodium "lithate," it was considered possible that the calculi form in the joints because the blood contains too much for the kidneys to eliminate, and this idea for many decades has been the principle underlying the therapy of gout.

Prévost and Dumas thus enunciated a new view of kidney function. That view has come down to the present as the working principle which guides the physiological chemist in much of his work on the chemistry of the blood and of the kidney secretion. In the course of a hundred years, however, with the development of organic chemistry and the invention of methods there has appeared such a refinement of procedure that micro methods have in a great many cases taken the place of the more cumbersome—but not less accurate—macro or gravimetric methods. Instead of the modern physiological chemist being required to perform operations of a drastic sort such as the complete removal of both kidneys, or compelled to work with large quantities of material, or to perform combustions over a coal fire, he takes, as is indicated in one of the current methods,[6] such a small quantity as ten cubic centimeters of blood and analyzes it for non-protein nitrogen, urea, creatine, creatinine, uric acid, and sugar, some of which are present in as small quantities as a few milligrams per one hundred cubic centimeters of blood. To these might be added calcium, chlorides, phosphates, amino nitrogen, cholesterol and the acetone bodies and still the list would be incomplete.

---

[6] Folin and Wu: *Journ. Biol. Chem.*, XXXVIII, 91 (1919).

Following the lead of Prévost and Dumas, and others who might be mentioned, the modern physiological chemist, armed with new weapons for research, is pushing his chemical studies back beyond the membranes of the kidney glomeruli and tubules to the blood, and discovering relations of inestimable value to medical science. The following words, written in 1821, are still worthy of attention in 1921:

> General hydropsy, hematuria and many other affections enter a new day when considered from this particular point of view. The characters of the kidney secretion acquire a very powerful interest in that they serve to indicate the condition of the mass of the blood and the typical changes to which this important fluid is subject.

For the scientist especially, the story of the past is the record of progress in methods through which problems are approached and in ideas which direct the activities of the investigator. He who inherits by virtue of his scientific lineage all of the achievements of by-gone days would do well not to exalt unduly his own efforts or fail to appreciate his debt to those who laid the foundations upon which the more modern structure is built. The substance that seems relatively simple to the modern chemist has not always appeared in this light; it has often been necessary to unravel a mass of seemingly conflicting data in order to reveal this simplicity. The chemistry of the blood in 1821 consisted essentially of a small body of facts concerning the blood-clot, the coagulable proteins, the coloring-matter, and a few soluble salts; the passing of a century has resulted in the advancement of this particular branch of knowledge almost to the rank of a separate science. The only standard by which the work of the present may be compared with that performed one hundred years ago is that of the scientific method itself; that our fore-fathers in 1821 used this method well is certified by the fact that their results have stood the test of time; whether or not the contribution of 1921 shall possess the same clear title to longevity depends upon the degree of keen insight into problems, the skill in the use of methods, and finally the measure of self criticism which may be existent among the present generation of investigators.